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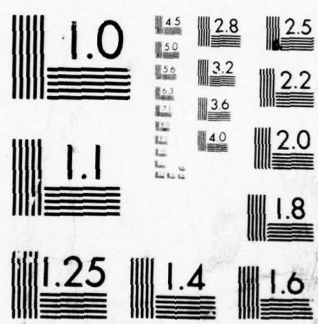

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THE EFFECTS OF REGULATORY CONSTRAINTS ON THE DELIVERY OF DoD WEAPONS SYSTEMS

Harold J. Brumm, Jr.
Robert W. Gilmer

July 1978

Prepared for

Office of the Under Secretary of Defense for Research and Engineering

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This paper presents an analysis of the economic effects that federal regulatory controls, especially environmental regulations and safety-and-health directives, have had on the US defense industrial base. Special reference is made to the ferrous foundry industry, since it has been alleged that the loss of production capacity in this industry has been heavily impacted by pollution control and safety-and-health requirements imposed by federal regulatory agencies.

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FOREWORD

This paper presents an analysis of the economic effects that federal regulatory controls, especially environmental regulations and safety-and-health directives, have had on the U.S. defense industrial base. Special reference is made to the ferrous foundry industry, since it has been alleged that the loss of production capacity in this industry has been heavily impacted by pollution control and safety-and-health requirements imposed by federal regulatory agencies.

This paper has benefited greatly from the comments of DoD officials Richard E. Donnelly, Jerome Persh, and Edward J. Dyckman. The authors, however, bear sole responsibility for the analyses, views, and conclusions presented. Nothing contained in this paper necessarily represents the official position of IDA or any of its DoD sponsors.

SUMMARY OF FINDINGS AND CONCLUSIONS

There is little question that environmental and health or safety regulations have had a major impact on American industry. These effects have probably been more significant in raising prices than in terms of actual closings or other loss of production capacity. Environmental Protection Agency (EPA) industry studies often show nominal price effects necessary to pass all direct control costs through to the consumer or to guarantee historical profit rates. These estimates of direct control costs in a particular industry fail to consider that major cost increases may result from pollution control in other industries acting as its suppliers and their price increases become additional cost increases. These cost increases tend to cumulate in a significant way in basic manufacturing. EPA's regulations in 1973 raised the price of all manufactured goods--the industries in which DoD concentrates its purchases--by perhaps 1.5 percent. The cost of a proposed noise control program by the Occupational Safety and Health Administration (OSHA), the only program for which detailed data were available, would have raised cost by nearly one percent more. The cost of other OSHA programs is unknown, but probably significant.

Much of the empirical evidence suggests that closings due to controls have not been a general or widespread problem. The Bureau of Economic Analysis (BEA) at the Department of Commerce has for several years conducted an annual survey of the effects of implementing pollution controls. A very small percentage (one to one and one-half percent) of the firms in the BEA survey have indicated that plants or production lines have closed

because of pollution control requirements. EPA's estimates of the cumulative number of closings due to pollution controls in industry is small.

Our estimates of the 1973 price increases were applied to the value of shipments to DoD by a number of defense-oriented industries; together these defense-oriented industries shipped $22.7 billion worth of goods to DoD under prime or subcontract. The cost of DoD of pollution controls on these shipments can be roughly estimated to be $294.5 million; and $199.5 million more would have been added if noise controls had been implemented. Together these programs would have accounted for a two and one-half percent escalation in the cost of these purchases.

Any reaction by DoD to these price increases is constrained by the fact that both DoD and the agencies that implement the controls belong to the same branch (i.e., the Executive Branch) of the federal government. This fact, combined with the laudatory social goals being pursued by these regulations, makes aggressive argument against control *per se* improper and impractical. DoD should, however, make clear to Congress and other members of the Executive Branch that as a major purchaser it is immediately and adversely affected by these regulations. Cost escalation in weapon systems must, in part, be explained by the effects of these regulations which are clearly beyond the control of even the most efficient contractors and weapon system project managers. Except for explicitly recognizing that price increases adversely affect its budget, and making some attempts to substitute out the products which are affected most severely from its budget, there is little DoD can do but accept price increases as the inevitable consequences of regulations.

And the fact that there have been no general problems with closings or capacity loss does not mean that DoD has not faced significant problems in this area. The imposition of a new regulation may result in the seemingly sudden loss of one or

more sources of supply. Often, in the comparatively thin and exotic markets in which DoD buys, this may be *all* of the sources of supply. Even if it is not, cost increases and longer lead-time for weapon systems result as production capacity has been lost.

There are several ways in which the Department of Defense can improve its ability to cope with the effects of regulatory problems. One of these has been suggested as developing and maintaining a better understanding of the effects of regulation on defense purchases. The calculations used in this paper and the methodology surveyed in the appendix suggest that this can be done easily and at nominal cost. Which industries are heavily impacted? Where are direct price increases highest? Which defense-oriented industries are affected? Organizations such as the Federal Preparedness Agency of the General Services Administration, Chase Econometrics, or the INFORUM project at the University of Maryland are capable of keeping track of these problems at nominal cost and using data they regularly maintain.

A second place for a general review of potential adverse effects on DoD is within the regulatory agencies themselves. The reviews they currently conduct to determine control technologies are highly technical and involve them deeply in industries' production methods; their economic impact studies involve them in the industries' markets. Only minor changes of emphasis can raise significant questions about the military implications of controls. Certainly these should be conducted if a regulation affects "defense-oriented" industries as defined by the Bureau of the Census. Absolutely no systematic consideration of the national security implications of these regulations is now made and DoD should perhaps seek to remedy this situation.

Since it is impossible to anticipate all of these problems, it is going to be easier and cheaper to simply respond to many

of them as they occur--if they can be responded to effectively. To do this, a focal point for such problems needs to be established and generally recognized. Experience with these problems has indicated that the proper channels for coping with them are almost always available. Ultimately, the problem becomes one of changing a specification, adopting irregular procurement procedures, or seeking additional funds--actions for which established channels exist. But the difficulty and time involved in working from the field where the problem arises through the bureaucratic problems of coordination and action should not be underestimated. The value of the focal point would be experience in handling the problems, and a working knowledge of both potential solutions and the people or groups who have the power to implement the solution. The logical place for such a focal point would be the Office of the Under Secretary of Defense for Research and Engineering (OUSDRE). Problems of this nature which involve one or more services (and most do) would be referred to either of two Directorates within OUSDRE--Materiel Acquisition Policy or Contracts & Systems Acquisition--as well as to the Deputy Assistant Secretary of Defense (Energy, Environment & Safety) in the Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs and Logistics, OASD (MRA&L) for technical review of standards and problems of implementation in DoD work places. The coordination and action problems among these offices would be greatly alleviated by the existence of a focal point, and his location within the Office of the Deputy Under Secretary (Acquisition Policy), OUSDRE seems natural in light of the existing staff organizations in DoD.

Chapter I

AN OVERVIEW OF THE IMPLEMENTATION AND IMPACT OF ENVIRONMENTAL, SAFETY, AND HEALTH REGULATIONS

This chapter is an overview of the economic effects of regulations imposed on American industry by the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA). There are many governmental regulators--the Federal Commerce Commission, the Federal Trade Commission, and the Internal Revenue Service, among others--so it is worth asking why these two agencies have been singled out. First of all, they are relatively new, both having been created since 1970, and since their creation both have implemented numerous regulations which have directly affected virtually every segment of American industry. Secondly, the regulations of both agencies have had similar effects to the extent they have forced cost and price increases, and they have forced the closing of some production lines. Those products most basic to manufacturing processes such as castings, forgings, coke, and pig iron have been among the industries most heavily affected by both agencies. There is little doubt that in many ways these agencies have been obstacles to the delivery of many basic manufactured commodities. The purpose of this chapter is to put the seriousness of these obstacles in perspective.

A. LEGISLATION AND LEGISLATIVE OBJECTIVES

1. <u>Environmental Protection Agency</u>

The Environmental Protection Agency (EPA) was established in the Executive Branch as an independent agency effective

December 2, 1970. It was created to permit coordinated and effective government action to assure the protection of the environment by abating and controlling air and water pollution. EPA maintains a variety of research, monitoring, standard setting, and enforcement activities related to pollution abatement with regard to all aspects of the environment. Although EPA's responsibilities cover vehicle emissions, ambient air standards, treatment of municipal sewage, oil storage and shipment, treatment of toxic chemicals, dumping at sea, and many other specific areas, this background considers only air pollution discharged by non-public sources. The choice of air pollution requirements stems from our choice of the ferrous foundry industry as an example.

The Clean Air Act provides national standards for ambient air quality, setting upper bounds for particulate matter, carbon monoxide, photochemical oxidants, and other irritating or harmful chemicals. Each state is required to devise a strategy to keep the air quality within the bounds of cleanliness prescribed by the Act. Although the federal government requires that certain monitoring devices be used and that certain record-keeping be performed, the plans are drawn up and implemented at the state (and in some cases, regional) level. States were given the option of strengthening these standards, but they have not generally done so. Regulations designed to meet these standards will vary substantially from state to state, however, as the control strategy varies.

2. The Occupational Safety and Health Administration

On December 29, 1970, the Williams-Steiger Occupational Safety and Health Act of 1970 was signed into law. In accordance with this Act, the Occupational Safety and Health Administration (OSHA) was formed in April 1971 as a bureau of the Department of Labor to administer the provisions of the Act. Congress declared the purpose of the Act and, hence, OSHA's

mission to be "...to assure so far as possible every working man and woman in the nation safe and healthful working conditions...." To implement this mission, Congress specifically outlined the following duties for OSHA"

- To encourage employers and employees to reduce hazards in the workplace and to improve existing safety and health programs.
- To establish employers and employee responsibilities as regards health and safety.
- To set mandatory job safety and health standards.
- To provide an enforcement program for these standards.
- To provide for reporting procedures on job injuries, illness, and fatalities.

The Act covers every employer in a business affecting commerce who has one or more employees. The Act does not affect workplaces covered under other federal laws, such as the Coal Mine Health and Safety Act or the Federal Metal and Nonmetalic Safety Act. Federal, state, and local government employees are covered under separate provisions.

The Occupational Safety and Health Act reflected Congressional impatience with the time span which would be involved if OSHA implemented job and safety standards using the usual interagency and judicial coordination process for Federal rule-making. Accordingly, the Act authorized the Secretary of Labor to promulgate *without comment* standards which are widely regarded as "consensus standards." By consensus standards are meant standards which have been either voluntarily accepted by industry through such organizations as the American National Standards Institute, American Society for Testing of Materials, and the National Fire Protection Association, or standards which would bring the regulations into conformance with other Federal regulations such as the Walsh-Healy Act or National Health Standards. Accordingly, in May 1971 wide ranging safety and health standards were promulgated without comment as consensus standards.

Most of these standards concerned plant safety, but Section 1910.93 of the *Federal Code of Regulations* now lists some 400 chemicals for which occupational exposure limits from dust or ionizing radiation were set. OSHA has only recently begun shifting its efforts from safety to health regulations. Numerous health standards are now being considered or pending as OSHA shifts toward a heavier emphasis in the health area. Noise, heat-stress, coke-emission control, and other new health standards could impose substantial costs on business and industry.

OSHA responsibility under the Occupational Safety and Health Act extends beyond Federal rule-making to the enforcement of its own regulations. In the past OSHA has set up a system of on-site inspections as a means of establishing compliance with its standards. Since not all five million workplaces could be covered by inspection, a system of priorities was established so that the following cross-section of workplaces would be included.

- Those in which catastrophies and other fatal accidents have occurred.
- Those from which valid employee complaints have been received.
- Target industries.
- Target health hazards.
- A random selection of workplaces by type and size.

Citations and fines result from any inspection revealing noncompliance with OSHA regulations.

3. Why Regulations?

The output of the firm is normally thought of as the product it sells. The costs of production are the value of materials, wages, capital costs, and the payment for the entrepreneurial ability to run the firm. These are the usual accounting

costs and are *internal* to the firm. But in production other outputs and other costs than those normally conceived may occur. The outputs are waste water, smoke, effluent discharges, production accidents, and long-term occupational disability. The costs associated with these outputs are not borne by the firm but by other members of society--rather than being included in the firm's accounting costs they are *external* to the firm. Air pollution costs are manifold: lung diseases such as emphysema, bronchitis, and the common cold are made more acute by pollution, and ttrememdous costs, through physical discomfort and drug and hospital expenses, are incurred by society as a whole. Water pollution may result in the loss of a fishing industry, recreational areas, or it may change a way of life for some people. These external costs of production are not reflected in the accounting records of producing firms nor in the price of the product.

One way to look at the regulatory efforts of EPA and OSHA is an attempt to have the producing firm and its customers bear a larger share of the external costs of production. Both EPA and OSHA have relied heavily on the mandatory adoption of designated control technology for pollution or personal protection. Firms are required to adopt a prescribed technology to control emissions and assure safety, or close down. The firm finds its accounting costs rising as controls are adopted and, as the firm stops polluting and provides a more healthful working environment, the external costs imposed on society are reduced. To cover costs and maintain profits the firm must raise prices; if the firm is unable to cover *all* costs of production at market prices, it must close its doors. Cost and price increases mean the firm and its customers will share the control costs through reduced profits to the firm and higher product prices to the firm's customers.

It is important to note that despite the fact that EPA and OSHA protect different groups--EPA shifts costs borne by

everyone affected by pollution back to the plant and OSHA shifts those external costs borne by the labor force back to the plant--both agencies have the same *economic* impact. At the level of the individual producer EPA and OSHA both impose new capital requirements and higher operating costs. It is no coincidence that, in a survey of closed foundries conducted by *Modern Castings* magazine, if EPA or OSHA was blamed for the closing they were, almost without exception, mentioned jointly.[1] At the plant level the main effect of both kinds of regulations are the same--higher *accounting* costs. Hopefully, however, total cost to society--accounting plus external costs--are reduced by such controls.

B. THE COSTS OF REGULATION

When we say business "pays" for pollution or safety/health controls, we mean this in only an immediate, out-of-pocket sense. As our discussion has indicated, these costs will be divided between the owners of the firm through reduced profits and the firm's customers who pay their share as higher prices. The owners of the firm may reduce capital spending as profits fall or absorb the loss as reduced income through smaller distributed profits. Keeping this potential distribution of control costs in mind, this section reviews the cost of compliance with EPA and OSHA regulation.

1. The Cost of Pollution Control

Table I.1 shows estimates released by the Council on Environmental Quality (CEQ) of the cost of pollution control resulting from federal environmental regulation. Total annual costs in 1973 were $6.4 billion and expenditures are expected to be $194.8 billion for the 1973-82 period. Note that over the decade the

[1]Raymond Walk, "Analysis of Shipment Trends and Foundry Fatalities in the U.S." (March 1975). Mimeographed and distributed by the American Foundryman's Association.

Table I.1. ESTIMATED INCREMENTAL POLLUTION CONTROL EXPENDITURES

(Billions of Dollars)

Pollutant/Medium	1973 O&M[a] Costs	1973 Capital[b] Costs	1973 Total[c] Annual Costs	1982 O&M Costs	1982 Capital Costs	1982 Total Annual Costs	Cumulative: 1973-82 Capital Investment[d]	Cumulative: 1973-82 O&M Costs	Cumulative: 1973-82 Total Costs
Air pollution									
Public	0.1	0.1	0.2	0.5	0.2	0.7	1.7	3.8	5.4
Private	2.2	1.2	3.4	12.4	7.2	19.6	47.6	81.1	127.9
Water pollution									
Public	1.1	0.1	1.2	1.4	1.3	2.7	16.6	12.8	24.4
Private	0.5	0.5	1.1	1.9	1.5	3.4	14.2	14.5	26.6
Radiation from nuclear power plants	n.a.	n.a.	n.a.	0.05	0.05	1.0	0.3	0.08	0.3
Solid waste									
Public	0.1	0.1	0.2	0.3	0.1	0.4	1.0	2.2	2.9
Private	0.1	<0.05[f]	0.1	0.5	<0.05[f]	0.5	<0.05[f]	2.3	2.3
Land reclamation surface mining[e]	0.3	0.0	0.3	0.6	0.0	0.6	0.0	5.0	5.0
Total	4.4	2.0	6.4	17.7	10.3	28.0	81.4	121.8	194.8

Source: Adapted from Council on Environmental Quality, *Fifth Annual Report*, Table 12, p. 175; R. Harmen, "Are Environmental Regulations Hurting the Economy?" *Challenge*, XVIII (May/June 1975), p. 31.

Note: Incremental costs are expenditures made pursuant to federal environmental legislation, beyond those that would have been made in the absence of this legislation.

[a]Operating and maintenance costs.
[b]Interest and depreciation.
[c]O&M plus capital costs.
[d]Actual investment in plant and equipment, cited here to indicate real resources cost.
[e]Only includes coal mining.
[f]Less than 0.05.

cost of pollution controls will quadruple with air pollution cost accounting for nearly 75 percent of the total. Most of these air pollution costs are due to controls imposed on auto emissions and the auto industry. It is also important to note the substantial role played by operating and maintenance (O&M) expenses in pollution control; in the cumulative data O&M costs outweigh capital expenditures by over 50 percent. This trend is again largely due to air pollution controls.

The total figure of $194.8 is to be divided as "out-of-pocket" expenses among business, consumers, and government. Of the total, some $77 billion is to be paid directly by consumers for auto emission controls and for solid waste disposal. The government and electrical utilities pay $32 billion each, and the remainder falls on industry. In summary, the public sector and electrical generating plants each paid one-sixth of the total, and the auto industry and all other industries paid one-third each.[1]

Table I.2 shows pollution abatement expenditures (PAE) for 1973 for 11 selected manufacturing groups, mining, and public utilities. The high level of operating cost is again seen in Table I.2 indicating that even after the "hump" of capital expenditures imposed by new regulations, the costs of pollution controls will remain with us into the future. Total pollution expenditure by industry in 1973 was $4.8 billion dollars divided almost equally between capital and O&M cost. This should make it a conservative estimate of a "typical" year based on the CEQ cumulative total of $43.8 billion being paid by industry from 1971-79, i.e., $5.9 billion per year in control cost. Because it is the only year for which good data exist on total control costs at the industry level, we will carry the 1973 expenditures as an example of representative annual effects of pollution control.[2]

Table I.2 also shows the ratio of PAE to sales in 1973. This figure represents the markup in price necessary for the firm to pass through 100 percent of PAE as price increases. This ratio is 4.58 percent for public utilities and 2.01 for petroleum, but otherwise under two percent. A nominal mark-up

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[1]R. Harmen, "Are Environmental Regulations Hurting the Economy?" *Challenge*, XVIII (May/June 1975), p. 31.

[2]How representative the distribution of this cost is among industries for years other than 1973 is an open question.

Table I.2. POLLUTION ABATEMENT COSTS FOR SELECTED INDUSTRIES IN 1973[a]

	1973 Pollution Abatement Expenditures (PAE)			1973 Sales	PAE AS A PERCENT OF 1973 SALES	PAE AS A PER-CENT OF 1973 PROFITS AFTER TAX	PAE AS A PER-CENT OF 1973 CAPITAL EXPEN-DITURES
	Capital	Operating	Total				
Iron & Steel Foundries	49.7	67.7	117.4	6,425	1.83	32.9	40.2
Other Iron, Steel	196.2	208.2	404.4	20,758	1.95		
Non-Ferrous Metals	189.8	93.5	283.3	22,981	1.23	24.4	18.3
Industrial Machinery & Fabricated Metal	159.1	225.3	384.5	184,633	0.21	3.6	2.2
Transportation Equipment	93.3	119.6	212.9	111,939	0.19	23.1	7.0
Textiles	26.9	35.8	62.7	28,016	0.22	8.2	8.6
Paper, Printing	319.6	220.1	539.7	30,107	1.79	41.2	28.5
Chemicals	364.9	462.9	827.8	63,499	1.30	15.4	20.8
Petroleum	296.7	311.2	607.9	30,305	2.01	7.8	15.3
Rubber	22.3	39.3	61.6	19,923	0.30	5.74	4.3
Other Manufacturing	--	--	920.6	285,426	0.30		
Mining	91.0	100.0	176.0	29,771	0.59	N/A	N/A
Public Utilities	1451.0	1451.0	2902.0	63,390	4.58	N/A	N/A

[a]All figures in millions of 1972 dollars. Sales and profits were deflated from data published in the *Survey of Current Business* for each industry; capital and pollution expenditures used the *Engineering News-Record* deflation for construction. Profits are for corporations only.

Sources: Bureau of the Census, *Pollution Abatement Costs and Expenditures: 1973*, MA 200(73)-2 (March, 1976) Washington, D.C.: USGPO; J.E. Cremeans, "Capital Expenditures by Business for Air and Water Pollution Abatement," *Survey of Current Business*, LVII (July, 1974); capital and profit data from various issues of the *Survey*.

will cover all PAE for most of these industries. If the firm is unable to pass PAE on as price increases, it will reduce profits and presumably reduce the earnings of the owners and capital expansion plans as well. The ratio of PAE to profits and capital expenditures in 1973 are shown in the two right-most columns of Table I.2. These ratios indicate that if the firm passed *no* PAE on as price increases and absorbed the entire amount of increased costs, the effect on profits and capital could be substantial. Metals, paper, chemicals, and transportation equipment are the most heavily impacted industries, but in no case is the ratio really inconsequential. We will see below, however, that it is thought that this cost is greatly reduced by subsidy and most of the remaining PAE expense is successfully passed on as price increases.

2. The Cost of Safety and Health

Unfortunately, no direct estimates comparable to the PAE data exist for the effects of OSHA's safety and health regulations. Estimates of some specific programs are becoming available, but no comprehensive estimates exist.[1]

Table I.3 shows the cost of one proposed OSHA program to control noise at the work place at a 90 decibels (dBA) level.[2] The average annual cost of the program for each industry is shown depending on whether the program is implemented over a three- or five-year period. The annual cost is shown as a percentage of sales, profits, and capital expenditures for each industry. The results are comparable to those of Table I.2--small price increases are needed to pass these costs on to

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[1]OSHA has now been required by the Council on Wage and Price Control to derive cost estimates of new regulations as Inflationary Impact Statements. The effects of past rulings will apparently not be studied.

[2]EPA is seeking to have OSHA implement a more stringent 85 dBA standard to bring it into line with that agency's own regulation. The costs will be substantially higher (perhaps doubled) if 85 dBA is adopted.

Table I.3. THE COST OF NOISE CONTROL IN PLANT

Industry	Annual Cost of Noise Control Program (90 dBA)		1973 Sales	Noise Control as Percent of 1973 Sales		Noise Control as Percent of 1973 Net Profits		Noise Control as Percent of 1973 Capital Expenditure	
	3 Year	5 Year		3 Year	5 Year	3 Year	5 Year	3 Year	5 Year
Iron, Steel Foundries	55	33	6,425	0.85	0.51	6.6	3.9	7.7	4.6
Other Iron, Steel	49	29	20,785	0.23	0.14				
Non-Ferrous Metals	172	103	22,981	0.75	0.45	4.2	2.5	11.1	6.7
Industrial Equipment & Fabricated Metal	1007	605	184,633	0.55	0.32	9.4	5.7	5.7	3.4
Transportation Equipment	338	203	111,939	0.30	0.18	36.7	22.0	12.0	7.2
Textiles	338	203	28,016	1.20	0.72	50.2	30.2	44.4	26.6
Paper, Printing	311	186	30,107	1.03	0.61	23.8	14.3	17.8	10.7
Chemicals	338	203	63,499	0.53	0.31	6.3	3.8	10.3	6.2
Petroleum	64	39	30,305	0.21	0.13	1.0	0.6	1.3	0.8
Rubber	92	55	19,923	0.46	0.28	2.8	1.7	6.4	3.8
Other Manufacturing	394	236	285,426	0.13	0.08			N/A	N/A
Mining	N/A	N/A	29,771	--	--	--	--	--	--
Public Utilities	983	590	63,390	1.55	0.93	N/A	N/A	5.6	3.4

*All figures in millions of 1972 dollars; same deflators as Table I.2. Profits are for corporations only.

Source: Table I.2; Bolt, Beranek, and Newman, *Impact of Noise Control at the Workplace*, Report No. 2671 (Cambridge, Mass.: 1972).

consumers, but a failure or inability to pass costs on could adversely affect profit or capital spending. The most striking thing about this program is its total cost figure of $11.8 billion. The average annual cost of a three-year program would be $3.8 billion, or only a billion dollars short of the cost to industry of *all* forms of pollution control in 1973. This is a substantial sum, and if the effects of OSHA's safety requirements, dust control, coke-emission, and other programs were known they undoubtedly would add quite substantially to this figure.[1]

3. Price Increases From Controls

a. Subsidies for Pollution Control and Safety/Health Regulation

The primary source of subsidies for installing controls and complying with EPA and OSHA regulations is the tax system. Interest expense and depreciation against installed capital equipment substantially reduce the cost figures cited above. Numerous other special financing arrangements and special tax provisions may also be available to some firms.

The annual cost of capital to the firm depends on the book depreciation of the plant (let d^B be the fraction of total investment used in any one year) and the cost of money to the firm ($r = r_b f_b + r_s f_s$, where r is the rate of interest, r_b is the rate paid on bonds, r_s the rate on equity, and f_b and f_s indicate the proportion financed by bonds and equity) in order to finance the plant. In the absence of any subsidies from the tax system the annual cost of capital (c) would be related to its market price (q) by the following relationship:

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[1] "There is little doubt that in some foundries the dollars spent on OSHA compliance already have exceeded the cost of pollution control equipment." W.O. Ferguson, "Living with the OSHAct," *Foundry Management and Technology*, (June 1976), p. 44. Foundries have been *heavily* impacted by air pollution costs.

$$c = q(d^B + r)$$

for a plant with a 20-year lifespan and using straightline depreciation $d^B = .05$; if $r = .10$, then $c = .15q$.

What happens if subsidies are introduced via the tax system? It can be shown[1] that the tax system changes this cost of capital to

$$c = q\left(\frac{d^B - \tau d^T}{1-\tau} + \frac{r - v\tau f_b r_b}{1-\tau}\right)$$

where

τ = marginal tax rate

d^T = proportion of capital allowed to be written off of income for tax purposes

v = fraction of the balance financed by bonds which remains unpaid.

The first term inside the brackets indicates that if tax and book depreciation coincide, the tax allowance for depreciation has no effect in differentiating the price of capital and the adjusted cost of capital. But fast tax depreciation ($d^T > d^B$) is a subsidy from the tax system and pushes the cost of capital downward. The Tax Reform Act of 1969 provides for rapid amortization of certified pollution control facilities over a 60-month period. If straightline depreciation is used by the firms, the Act allows 20 percent of the cost of the equipment to be written

[1]See the appendix at the end of this paper, which discusses in greater detail a number of aspects of the "cost" methodology used throughout this chapter. The appendix points out numerous qualifications of the data that are glossed over here, and the actual figures derived in the paper should be regarded more as examples of the line of thinking adopted than conclusions immediately useful for policy. The sources of potentially better and more detailed data are considered in the appendix.

off against income during each of the first five years following installation. The result is $d^T = .20$ for the first five years the pollution control facility operates. Quicker depreciation methods may actually be used than straightline in some cases, but their advantage in recent years has to be weighted against job development tax credits such as those made available in the Tax Reform Act of 1971. These credits permanently reduce the tax liability of the firm by an amount equal to 7 to 10 percent of its total capital expenditure. Only straightline depreciation is available if the tax credit is used, and only straightline depreciation is used for purposes of the examples in this paper.

We saw above that $c = .15q$ if the tax system is ignored. How much does the tax system reduce this cost? For $r = .10$ and $d^B = .05$ as assumed before, $d^T = .20$ as the tax law allows, and if $\tau = .50$, $v = 1.00$, $f_b = .5$, $r_b = .12$, then $c = .04q$. This is a 73.3 percent reduction in the cost of capital. If we allowed for a seven percent tax credit this would reduce the cost even further by $.07\tau q = .035q$ dollars per unit, or very nearly to zero for the first year of the project. The 73.3 percent reduction in capital cost has been used in the computation of the figures that follow.

All operating expenses for approved pollution control equipment can be completely written off against income to figure the tax base. This results in savings of one-half of all operating expenses due to the tax system. The result is that the cost of a pollution control facility can be approximated over the early years of its life as $.27K + .50E$, where K is the annual market cost of capital facilities and E is the operating expense.

Numerous other tax advantages may exist for particular firms. Some firms, for example, may be given access to tax-free financing in the municipal bond market under the industrial

revenue bond program.[1] Many banks are authorized to give special preference to loans for pollution control to smaller businesses at rates normally reserved for major corporations.[2] These may result in large or small tax savings for particular firms in addition to those tax savings discussed above, but they are probably not large in the aggregate.[3]

Table I.4 shows the total cost of controls computed in Table I.3, and it shows these same costs net of tax savings. Tax savings for capital expenditures for pollution controls reduces the cost in Table I.2 by 73 percent; current pollution control expenses fall by 50 percent. For OSHA and noise control all expenditures are assumed to be reduced by 73 percent by tax savings because noise control is virtually all capital improvement. But OSHA safety programs (for which the cost is unknown) are mostly current expenses which cannot be reduced by as large a fraction as the capital expenses.[4]

b. Pass-Through of Control Costs

Most studies have concluded that much of the cost of pollution control is passed to the consumer through higher prices. Recent studies of the micro-economic aspects of pollution control have put the rate of pass-through at 90 percent or more;

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[1]G. E. Peterson and H. Galper, "Tax Exempt Financing of Private Industry's Pollution Control Investment," *Public Policy*, 23 (Winter 1975), p. 81.

[2]J. A. Commins and Associates, Inc., "A Localized Study of Gray Iron Foundries to Determine Business and Technical Commonalities Conducive to Reducing Abatement Cost" (January 1972) Fort Washington, PA, pp. 3-17, 22.

[3]Peterson and Galper, *op. cit.*

[4]Efforts by the Carter Administration have been to de-emphasize the safety programs which have been hard to enforce and widely regarded as a nuisance by the business community. The increased worker safety resulting from a plethora of trivial, sometimes conflicting, regulations has been small and the cost in both money and bad relations for OSHA have been substantial. Emphasis within OSHA is currently shifting strongly in favor of health rather than safety standards.

Table I.4. EXPECTED COST INCREASES FROM POLLUTION AND NOISE PROGRAMS NET OF SUBSIDIES ($ 1972)

	Cost of Controls		Cost of Controls Net of Tax Savings			Percentage Mark-Up in Price		
Industry	EPA	3 Year Noise	EPA	3 Year Noise	Percent of Cost Passed Through As Price Increases	EPA	3 Year Noise	Total
Iron, Steel Foundries	117.4	55	46.8	14.3	1.00	0.73	0.22	0.95
Other Iron, Steel	404.4	49	155.1	12.7	1.14	0.85	0.07	0.92
Non-Ferrous Metals	283.3	172	96.1	44.7	1.03	0.43	0.20	0.63
Industrial Equipment & Fabricated Metal	384.5	1007	154.0	262.0	0.95	0.06	0.13	0.19
Transportation Equipment	212.9	338	84.1	87.9	0.81	0.06	0.06	0.12
Textiles	62.7	338	66.7	187.9	1.02	0.02	0.18	0.20
Paper, Printing	539.7	311	295.8	80.9	0.97	0.95	0.26	1.21
Chemicals	827.8	338	326.3	87.9	0.92	0.47	0.13	0.60
Petroleum	607.9	64	225.7	16.6	1.16	0.86	0.01	0.87
Rubber	61.6	92	25.4	23.9	0.82	0.01	0.01	0.02
Other Manufacturing	920.6+	394	349.8	102.4	0.81	0.10	0.03	0.13
Mining	176.0	N/A*	73.6	N/A*	0.95	0.23	N/A*	0.23+
Public Utilities	2902.0	N/A*	1102.8	N/A*	0.80	1.39	N/A*	1.39+

*Not Available. Assumed zero for calculations of price increases in Table I.5.

+Assumed divided--half capital and half operating expenses

Sources: Tables I.2, I.3. David Gilmartin, *Forecasting Prices in an Input-Output Framework*, INFORUM Research Report No. 16, 1976. These are averages of Gilmartin's estimates of cost pass-through by input-output sector weighted by 1972 sales.

one recent study by Chase Econometrics put the price increases due to pollution control at 85-100 percent of cost for all industry.[1] Borrowing from a recent study of the ability of firms to increase prices in the face of new costs,[2] Table I.5 shows the estimated percentage of cost increases passed on to customers via price markups. Columns (2), (3), and (4) show cost increases necessary to pass *all* control costs on to customers, and column (5) is the sum of these increases. (Column (4) is unknown, but it is presumably a positive--and possibly substantial--sum so that (5) is a lower bound on expected price markups.) The markups are differentiated for OSHA noise control depending on whether a three- or five-year period is used to implement the program. The last column shows the expected markup in prices in the face of rising costs. The percentage of cost passed through via price increases by each industry is shown in Table I.4. Most of these increases are near unity, i.e., the cost is almost completely passed through. Rubber and transportation equipment have historically passed through only 80 percent of these costs in the short or intermediate run;[3] steel and petroleum have price increases *exceeding* actual cost increases. The last three columns of Table I.5 show the expected markup in price for each industry due to EPA and OSHA; these are based on both their increased costs and each industry's track record of increasing prices in response to these new costs.

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[1]Harmen, *op. cit.*

[2]David Gilmartin, *Forecasting Prices in an Input-Output Framework,* INFORUM Research Report No. 16, University of Maryland (1976).

[3]In the longer run, we might expect significant adjustments in the relative use of many of these products as substitution against more expensive inputs will occur. Indeed, this possibility may deter many industries from "excessive" markups. Other determinants of the markup will be the market structure of the industry including the number of firms. Collusion among a few firms in a small industry could induce higher markups than would otherwise be the case. A highly competitive industry will, in the long run, pass through 100 percent of the new cost but its overall capacity will change as some firms probably will close their doors. This is discussed further below.

Table I.5. PRICE INCREASES CAUSED BY INITIAL MARK-UPS DUE TO POLLUTION CONTROL

Industry	Initial Percent Mark-Up in Price Due to Controls	Percent Total Price Increases After All Subsidies				EPA Price Projections 1971-1976
	All Sources	EPA	1973 3 Year Noise	Other OSHA	Total	
Iron & Steel Foundries	0.95+	3.14	1.27	+	4.36+	1.7 - 5.0
Other Iron, Steel	0.92+	2.16	0.87	+	3.08+	.7 - 1.5
Non-Ferrous Metals	0.63+	3.71	1.48	+	5.19+	0 - 8.0
Industrial Equipment & Fabricated Metal	0.19+	1.53	0.98	+	2.51+	--
Transportation Equipment	0.12+	1.20	0.86	+	2.06+	--
Textiles	0.20+	1.23	1.16	+	2.39+	--
Paper, Printing	1.21+	2.27	1.02	+	3.29+	3.5 - 10.0
Chemicals	0.60+	1.68	1.28	+	2.96+	--
Petroleum	0.87+	2.63	0.83	+	3.46+	1.9
Rubber	0.02+	1.57	0.86	+	2.43+	--
Other Manufacturing	0.13+	1.21	.59	+	1.80+	--
Mining	0.23+	1.66	1.04	+	2.70+	--
Public Utilities	1.30+	2.35	0.28	+	2.63+	2.8 - 10.7*
All Manufacturing	.53+	1.54	.86	+	2.40+	

*Electric generators only.

These figures are the markup expected due to the *direct* imposition of controls. As we will see in the next section, they are not the total price increase resulting from controls, but only the first of a series of price increases.

c. Price Increases

Most of the cost of pollution or safety/health regulation can be passed through to other firms or to consumers. The markup shown as a percentage of sales in Table I.5 is generally fairly small. However, this initial markup in price should be only the first round in a series of price adjustments resulting from the control effort. This is simply because much of basic manufacturing sells extensively to other firms forcing costs upward again. Presumably, these initial markups will be passed on *again and again* by these firms. Suppose, for example, petroleum marks up its price the percentages we have predicted and all other firms do the same. The result is that petroleum--which must buy inputs from mining, industrial machining, etc.--finds its costs boosted upward by price increases in supplying industries. Petroleum pushes its prices up in response and other industries find their cost pushed upward in turn.

The total price increases, assuming *all* rounds of increases have been completed, were estimated for the pollution control costs of 1973, for the effects of a three-year noise control program for OSHA as if it had been implemented in 1973, and for the price effects of the two combined.[1] These estimates assume:

[1]Let $\emptyset^{(0)}$ be a vector of the initial price markups. If A is the open Leontief matrix describing the technology of the economy, then $A'(\emptyset)^{(0)} = \emptyset^{(1)}$ is the first round response to this markup; $A'(\emptyset)^{(1)} = \emptyset^{(2)}$ is the second round, and so on. The matrix A weights each price increase according to the amount of each input the firm purchases. The *total* price change is

$$\begin{aligned}\emptyset^{(n)} &= \emptyset^{(0)} + A'(\emptyset)^{(0)} + A'(\emptyset)^{(1)} + A'\emptyset^{(2)} + \ldots \\ &= (I + A + A^2 + A^3 + \ldots)'\emptyset^{(0)} \\ &= (I - A)^{-1}\emptyset^{(0)}.\end{aligned}$$

(continued on next page)

(a) markups occur in accordance with Table I.5; (b) all firms respond immediately to these price increases and, in the short-run, do not adjust their technology in response to the relative shifts in prices; and (c) consumers and labor accept these price increases (at least in the short run) and make no increased wage demands in response to them. Table I.5 indicates that the *total* effect of these markups is no longer small. Non-ferrous metal is the most heavily impacted industry with pollution controls forcing a 3.71 percent increase in price, the annual cost of noise control increases price 1.48 percent, and since other OSHA safety costs probably are significant (though unknown) the total increases exceeds 5.19 percent. Petroleum, mining, chemicals, paper, foundries, and other iron and steel have price increases of about three percent or more.

For all manufacturing the results suggest that EPA requirements could increase 1.54 percent; if noise controls had been implemented it would have again increased cost 0.86 percent. Together the totals exceed 2.40 percent for manufacturing. And these estimates substantially exceed EPA's own estimates of price increases in several cases. Drawing from a series of studies performed for EPA, the last column of Table I.5 shows EPA projections of *cumulative* price increased due to the imposition of pollution controls for the 1971-1976 period.[1] Our estimates of 1973 control costs *alone* are in several cases close to their *five year cumulative estimates.* The difference is the failure to adequately account for the interdependence in the economy

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(contd) The "leakage" from this system is through value-added which implies that consumers and the owners of the firm divide the effects of the price increases between them. A more realistic model might include the attempts of labor to adjust their wages in response to price increases—an effort which would only force prices higher in this model. This is discussed further in the appendix.

[1] Environmental Protection Agency, *The Economic Impact of the Federal Environmental Program,* (Washington, D.C.: USGPO, 1974), Table IV-1. But these are *direct* impacts only.

and the cumulation of price increases resulting from the initial price markups and markups by supplier industries. EPA does, in some studies, compute the total price impact of pollution control programs, but the results are published only in highly aggregated form as part of their macroeconomic data.[1] The total price changes would seem to be far more relevant for assessing an industry's position after controls are imposed than the direct effects alone would be.

C. CONTROLS AND INDUSTRIAL CLOSINGS

The price increases estimated above suggest that they could be fairly substantial and that some industries will be more severaly impacted than others. This suggests the possibility that price increases forced by controls could make some products commercially less attractive and others relatively more attractive. Industries heavily affected could see their sales decline as they pass through higher control costs than some competing products in other sectors. The result will be that less capacity is needed in heavily affected areas and closings of production lines and firms will occur as the heaviest pollutors tend to shrink.

Taken at face value, much of the empirical evidence available suggests that closings have not been a general, widespread problem. The Commerce Department's Bureau of Economic Analysis (BEA) has for several years conducted an annual survey of the effects of implementing pollution controls.[2] A very small percentage (one to one and one-half percent) of the firms in the BEA survey indicated that plants or production lines have actually closed because of pollution control requirements.

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[1] Chase Econometrics, "The Economic Impact of Pollution Control: Macroeconomic and Industry Reports" (March 1975). Prepared for the Council on Environmental Quality.

[2] *Survey of Current Business*, July issues.

Table I.6 indicates EPA's estimates of the cumulative number of closings expected during the 1972-76 period due to pollution controls. The total number of closings in the economy is small.

Table I.6. EPA ESTIMATES OF CLOSINGS DUE TO POLLUTION CONTROLS

Industry	Closures	Employment Loss
Iron Foundries	400	16,000
Steel	0	0
Non-Ferrous Metals	3+	1,350+
Pulp and Paper	60-65	16,000
Petroleum	12	1,000
Electric Power Generation	0	0
Total	600-605	41,350

Source: EPA, *Economic Impact, op. cit.*

Though some specific sectors are clearly damaged, e.g., 500 closings in the foundry industry, the overall growth rate of most broad industry groups seems to be little affected by pollution controls. The effect on capital spending (defined as the sum of industrial plant and equipment purchases plus residential construction) of pollution regulations is apparently slight. Chase Econometrics has estimated that a dollar spent on pollution control will displace 40 cents of capital investment. But much of this displacement will occur in residential construction and not industrial plant and equipment purchases.[1] Indeed the high industrial pass-through of pollution control costs via price increases makes a displacement of over 10-15 percent unlikely. And the annual surveys conducted by the Bureau of Economic Analysis[2] firmly support this contention that pollution control costs have little effect on

[1]Cited in EPA, *Economic Impact, op. cit.*

[2]*Survey, op. cit.*

capital accumulation. Among the firms sampled, only two percent of the plants sampled claimed to have reduced their current capital expenditures because of pollution abatement requirements. The relative size of these industries similarly is only slightly dependent on pollution controls. One study has indicated that the capital required per dollar of output could climb by as much as six percent in some sectors due to pollution capital requirements, but indicated no change in the *relative* growth rates of these industries due to the effect of controls.[1] The overall growth rate was affected, but the share of each industry remained remarkably constant.

Putting these results in perspective, the costs of controls are relatively small compared to the total output of goods in this country. The effects of the controls from this broad, macroeconomic viewpoint probably should look small when painted on such a broad canvas. This does *not* imply that specific products or specific segments of the economy are not heavily impacted, however, or that adverse conditions do not exist because of control legislation. The next chapter is a detailed look at the economic problems caused the ferrous foundry industry by air pollution regulations. As the 400 closings of ferrous foundries indicate, that industry has been adversely and heavily impacted by control regulation.

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[1]A. P. Carter, "Energy, Environment, and Economic Growth," *The Bell Journal of Economics and Management Science*, 5 (Autumn 1974), pp. 578-92.

Chapter II

THE EFFECT OF EPA AND OSHA REGULATIONS ON THE FERROUS FOUNDRIES

The previous chapter has provided some empirical evidence on the impact that EPA and OSHA regulations have had on the defense industrial base generally. The present chapter will detail the theoretical implications of those regulations for one component of the defense industrial base, viz., the ferrous foundries--gray iron, malleable iron, and steel. Specifically, in this chapter we shall attempt to determine on *a priori* grounds the supply response that can be anticipated from foundries when such regulations are imposed. In the following chapter, we shall examine some of the problems these regulations pose for DoD.

A. THE FOUNDRIES: BACKGROUND INFORMATION

There exist two fairly distinct groups of firms comprising the ferrous foundry industry--jobbing foundries and production foundries.[1] Job shop foundries tend to be relatively small operations which are usually family-owned or held as small closed corporations without outside equity capital, and produce a wide variety of castings which vary by quantity, size, weight, and technical specifications. This lack of specialization in terms of outputs greatly reduces the possibilities

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[1]A third group of foundries could be broken out from these two, viz., cast iron pipe foundries. Of course, even more detailed taxonomies of the "industry" are possible. But, for our purposes here the dichotomy between jobbing and production foundries seems satisfactory.

for mechanization of the job shop's production techniques. As a result, 40 to 70 man-hours of labor input may be expended per ton of castings shipped. By contract, production foundries, which also produce a wide variety of castings, tend to be less labor intensive and make use of extensively mechanized production techniques. The labor input expended per ton of castings shipped usually is in the range of 15 to 30 man-hours.

Foundries may also be classified by the size of sales. A look at the differing impacts of EPA regulations on small versus large foundries is instructive. Table II.1 shows some financial data for foundries of different sizes which were not subject to environmental and safety controls in 1971. These data are limited to firms that produce castings by pouring liquid metals from cupolas--as opposed to furnaces--into molds. It is evident that the larger foundries were the more profitable operations. Table II.2 shows estimates of the cost of EPA and OSHA controls. Note that the small foundries require at least a 4.7 percent markup of product price, in order to cover the cost of EPA and OSHA regulations, whereas for intermediate-size and large firms the markup required is at least 3.3 percent and 1.2 percent, respectively. These percentages are direct control costs only--they do not include an allowance for markups attributable to those cost increases which foundries experienced when the firms from which foundries purchase produced inputs raised the prices they charge the foundries for those inputs as a result of their own cost increases, the latter increases occurring when, due to the direct control costs, foundries raised the prices of castings sold to those firms.[1] (There are, of course, firms which not only *purchase* castings from foundries, but also *sell* produced inputs to foundries.)

[1]Cf. *supra,* n. 1, p. 23. The input-output theory underlying this explanation is presented in R. Dorfman, P. Samuelson, and R. Solow, *Linear Programming and Economic Analysis* (New York: McGraw-Hill, 1958), pp. 234-37.

Table II.1. SIZE OF FOUNDRY BY ANNUAL SALES
(All figures in thousands of dollars except rate of return and sample size)

Accounts \ Sales	Under 500	1,000 to 2,500	Over 10,000
Gross Receipts	264	1,723	21,162
Operating Expenses	251	1,620	20,464
Gross Profit	13	113	698
Taxes	4	38	179
Net Profit	9	75	519
Depreciation	4	52	549
Total Assets	182	864	9,015
Return on Assets	4.9%	8.7%	5.7%
Sample Size	60	38	2

Source: A.T. Kearney and Company, Inc., *Study of Economic Impact of Pollution Control on the Iron Foundry Industry*, Part II, NTS Publication PB-207 148 (Nov. 1971), Exhibits 29-31. (Available from National Technical Information Service.)

Notes: Return on Assets = Net Profits/Total Assets.
Sample Size = Number of Firms Surveyed.

Judging from the analysis of the first chapter,[1] perhaps these markups should be tripled, resulting in a range of markups of 3.5 percent to 14 percent, depending on the category of foundry size.

The foregoing discussion has provided some sketchy empirical evidence on the impact that EPA and OSHA regulations have had on foundries. Obviously, much more data and better quality data would have to be scrutinized before any credible quantitative inferences could be drawn about what economic effect EPA

[1]See *supra*, pp. 19-23.

Table II.2. SIZE OF FOUNDRY BY ANNUAL SALES
(All figures in thousands of dollars--
except mark-up)

Sales / Costs and Receipts	Under 500			1,000 to 2,500			Over 10,000		
	Pollution	Noise	Other OSHA	Pollution	Noise	Other OSHA	Pollution	Noise	Other OSHA
Expenses Associated with Controls	10.4	7.9	NA	64.0	19.7	NA	305.0	52.3	NA
Tax Savings Due to Controls	3.4	2.6	NA	19.0	6.3	NA	92.0	15.8	NA
Net New Cost	7.0	5.3	NA	45.0	13.4	NA	213.0	36.5	NA
Gross Receipts	264.0			1,733.0			21,162.0		
Total Net New Cost	12.3			58.4			249.5		
Mark-up to Cover Direct Cost (%)	4.7			3.3			1.2		

Sources: A.T. Kearney, *op. cit.*; and Bolt, Beranek and Newman, Inc., *Impact of Noise Control at the Workplace*, Report No. 2671, a report submitted to the U.S. Department of Labor, Office of Standards, January 1, 1974. (Available from the OSHA Technical Data Center, Room N3620, 200 Constitution Ave., N.W., Washington, D.C. 20210.)

Notes: Net New Cost = Expenses Associated with Controls-Tax Savings Due to Controls
Total Net New Cost = Net New Cost Due to Pollution and Noise Controls.
Mark-up = Total Net New Cost/Gross Receipts.
NA = Not Available

and OSHA have had. However, as we shall see in the next section, we can make some qualitative inferences about that impact.

B. FIRM AND INDUSTRY RESPONSE TO EPA AND OSHA REGULATIONS

It will be convenient to make several simplifying assumptions at the outset. First, let us assume that "the market" for iron and steel castings--the principal output of the ferrous foundries--is perfectly competitive.[1] This assumption would appear to be a reasonable first approximation of the industry's market structure. On the *supply* side, the industry includes a large number of many small firms. At the present time, 82 percent of all foundries employ less than 100 workers; 50 percent employ fewer than 20 workers.[2] On the *demand* side, iron and steel castings are commonly intermediate to a wide variety of final manufactured goods. For example, metal castings are required as end products or component parts of 90 percent of all durable goods manufactured in the United States.[3] Furthermore, most of the industry's output is purchased by private firms. For example, less than five percent of that output was purchased by local, state, and Federal government agencies in 1972.[4]

The effect of EPA and OSHA regulations that remain unaltered for a specified interval of time is to require the foundry to purchase pollution abatement and safety equipment.

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[1]As mentioned above, the products of this "industry" are not homogeneous. Strictly speaking, therefore, at least one of the assumptions of the model of perfect competition is violated.

[2]Debbie Tennison, "The Foundry Industry--Achilles' Heel of Defense?" *National Defense,* LX (March-April 1976), pp. 366-69.

[3]*Ibid.*

[4]U.S. Department of Commerce, Bureau of the Census, *1972 Census of Manufactures, Industry Series: Ferrous and Nonferrous Foundries--SIC Industry Groups 332 and 336,* MC72(2)-33B (Washington, D.C.: USGPO, 1974), pp. 33B3-33B4.

Thus, for a given time period, this expenditure requirement is tantamount to a lump-sum tax, i.e., a tax which does not vary with the firm's level of production or profit. Such a tax appears as a constant subtracted from the firm's total revenue for the given period. Other things being equal, as long as the level of the tax does not change, the firm's level of production will remain unaltered--provided that the tax does not raise the foundry's overall costs to such a level that the firm is forced out of business. A lump-sum tax which remains constant during a given period does not affect any surviving firm's production level because the production level which maximized net revenue before the subtraction of a constant also maximizes net revenue after subtraction.[1] Such a tax cannot affect the firm's internal allocation of its resources; it can only influence whether to operate or shut down.

Suppose, however, that with the passage of time the level of the lump-sum tax is increased. This assumption seems reasonably consistent with the casual observation that EPA and OSHA regulations imposed on foundries have risen rather steadily during the past few years. As the required expenditures on pollution abatement and safety equipment rise, the firm's long-run average cost will increase for every level of output. Hence, long-run supply price for the industry will increase and industry output will decline. This reduction in aggregate output will be accomplished by an exodus of firms from the industry. The conventional economic theory of the firm predicts exactly that result.

In addition to the theoretical prediction that EPA and OSHA regulations have had an adverse impact on the foundries, there is some evidence--albeit exiguous--that at least a partial explanation for the foundries' dilemma can be found in EPA and

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[1]We are implicitly assuming that the firm's objective is to maximize profit, i.e., net revenue.

OSHA directives. During calendar years 1971 through 1974, there were 287 foundries which went out of business.[1] Foundrymen are quick to point out that this avalanche of foundry closings began with 159 closings in calendar year 1971[2]--the first full year of EPA's and OSHA's existence. Whether this (positive) correlation between foundry closings and EPA/OSHA regulations is statistically meaningful remains to be seen--as yet there exists very little "hard" evidence which would permit a really thorough empirical testing of the (null) hypothesis that EPA and OSHA regulations have had no significant detrimental impact on the industry's production capacity.

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[1]Tennison, "The Foundry Industry," p. 369.

[2]*Ibid.*

Chapter III

THE EFFECT OF EPA AND OSHA REGULATIONS ON THE DEPARTMENT OF DEFENSE

This chapter is a brief survey of the effects of EPA and OSHA regulations on the Department of Defense, and of the efforts of the Defense Department to cope with such regulations. The most immediate effect of EPA/OSHA regulations is on prices and, as we shall see, DoD has little choice but to accept increased prices for its weapon systems. Given that the EPA/OSHA regulations do cause closings and shutdowns of plants and production lines, how can DoD cope with these problems? Is it better to try to anticipate them, or should DoD simply wait until the problems surface and react to them? And, finally, what are the needs for wartime "surge" capacity, and do these regulations jeopardize this capacity? To answer this last question, we will return to the foundry example.

A. PRICE INCREASES

The most immediate effect of EPA and OSHA regulations on DoD is on the price of the goods it buys. DoD is one of the few government agencies buying heavily from the basic manufacturing industries heavily affected by these regulations. DoD's budget is affected very directly by regulation, and the effects of this regulation need to be more clearly understood.

For example, suppose the 1973 price increases for various industries which we estimated to result from controls were applied to DoD purchases. How much did DoD pay for pollution and noise control? Table III.1 shows the value of shipments

Table III.1. INCREASED COST TO THE DEFENSE DEPARTMENT DUE TO POLLUTION AND HYPOTHETICAL NOISE CONTROL IN 1973

(Millions of 1972 Dollars)

Industry	Value of Shipments to DoD	Percent Mark-up Attributable Pollution	Percent Mark-up Attributable Noise	Increased Cost Pollution	Increased Cost Noise
Chemicals	176.6	1.68	1.28	2.9	2.2
Petroleum	283.0	2.63	.83	8.2	2.3
Rubber	75.1	1.57	.86	1.2	.6
Steel Foundries	23.6	3.14	1.27	.7	.3
Non-Ferrous Metals	87.8	3.71	1.48	3.1	1.3
Fabricated Metals and Machinery	7,886.9	1.53	.98	118.9	76.5
Transportation	13,640.6	1.20	.86	161.7	116.3
Total	22,672.5			294.5	199.5

Sources: Bureau of the Census, "Value of Shipments by Defense Oriented Industries, 1973," (MA175), Table 4; Chapter I of this report, especially Table I.5.

to DoD by several large suppliers; together these defense-oriented industries shipped $22.7 billion worth of goods to DoD under prime or sub-contracts. Using the markups derived earlier, the part of the value of these shipments attributable to regulation can be estimated as shown on the right side of Table III.1[1] The cost to DoD of pollution controls among these seven industries was $294.5 million; and $199.5 more would have been added if noise controls had been implemented. Together this would have accounted for a two and one-half percent escalation in the cost of all of these purchases. Clearly, the sums involved are substantial.

Any reaction by DoD to these price increases is constrained by the fact that both DoD and the agencies that implement the controls belong to the same branch (i.e., the Executive Branch) of the federal government. This fact, combined with the laudatory social goals being pursued by these regulations, makes aggressive argument against control *per se* improper and impractical. DoD should, however, make clear that as a major purchaser it is immediately and adversely affected by these regulations. Cost escalation in weapon system must, in part, be explained by the effects of these regulations which are clearly beyond control of even the most efficient contractors and weapon system project managers. Except for explicitly recognizing that price increases adversely affected products from the budget, there is little DoD can do but to accept price increases as the inevitable consequences of regulations.

B. PROBLEMS OF ADMINISTRATION AND COORDINATION

Higher prices are one effect of EPA and OSHA on the day-to-day operations of DoD, but by forcing some plants and

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[1]These are estimated by applying the *total* percentage price to the value of the shipments. The price changes are from Table I.5. The appendix discusses this in more detail.

production lines to close, other regulations may also force delays or cost penalties in the production of weapon systems. These problems have arisen in the past and will continue to arise in the future as various regulatory constraints are implemented. Affected by these problems, and involved in remedial efforts to respond to them, are a wide range of military departments, agencies, steering committees, special interests, and other groups. A problem as diverse as that posed by environmental/safety/health regulations will necessarily affect many interest groups and involve special problems of administration and coordination. We will briefly survey the cast of characters with respect to their roles relative to DoD, and try to point out the problems that arise in day-to-day efforts to cope with these problems.

1. EPA/OSHA

The role of these agencies as regulators has been reviewed above. Both agencies are required to report on the economic impact of their regulatory efforts, but no specific emphasis is given to DoD or the national security implications of these regulations. The DASD(EE&S) has, however, formally expressed concern to OSHA and EPA about the adverse impact on national defense of proposed standards for beryllium, nickel, chlorofluorocarbons, and lead. EPA and OSHA make no effort to seek these problems out, even though DoD should perhaps receive special consideration both as a large purchaser and as a member of the Executive Branch of the Government.

2. Military Department

The military department developing a weapon system is most immediately affected by regulatory efforts having adverse effects that may go undetected until problems arise. The imposition of new, more stringent reflutations may result in the seemingly sudden loss of one or more sources of supply.

Often, in the comparatively thin and exotic markets in which DoD buys, this may be *all* of the sources of supply. Even if it is not, cost increases and longer lead-times for weapon systems result as production capacity shrinks. Remedies may range from finding an alternative source of supply to finding a substitute material, or to having DoD assume the production process itself. None of these remedies is simple within the complex bureaucratic procedures needed to deliver a weapon system; they may all involve redesign, meeting or devising new specifications and standards, retesting of the product, qualifying a new producer, or meeting complex procurement regulations. And the needed changes can take several years in some cases, such as specification changes for materials widely used in DoD weapon systems.

3. Office of the Under Secretary of Defense for Research and Engineering (OUSDRE)

The Deputy Under Secretary for Acquisition Policy within OUSDRE has the responsibility for assuring the integrity of the industrial base needed to support the production of the military departments. This includes the interface between the military departments and civilian economy that is common to all services. If a regulatory problem has an impact affecting two or more services (and this is often the case), its resolution is coordinated by OUSDRE. Its responsibility includes not only the effect of regulation on the delivery of current weapon systems, but also the maintenance of "surge" capacity for a wartime mobilization. Indeed, responsibility for a problem of this sort is divided several ways even within OUSDRE. The problem could land on the desk of several Directors, e.g., for Material Acquisition Policy or for Contracts and Systems Acquisition. The coordination and action problems are needlessly confused by this division of authority.

4. Materials Availability Steering Committee

This committee began as a coordinating committee within the Department of Defense, and has since expanded to include regulatory members such as EPA and OSHA, and other governmental agencies (such as the Department of Commerce, the Department of the Interior, and the Federal Preparedness Agency Agency.) The interests of this committee span all aspects of the delivery of raw and processed materials to the Department of Defense. The effects of EPA and OSHA on the Department of Defense are one special interest of this Committee.

5. Other Considerations

To discuss problems of administration, it is easiest to divide the efforts to handle the effects of regulation into two parts. First are efforts to forecast or anticipate problems resulting from the promulgation of regulations before they arise; second are efforts to respond to problems once they are realized.

Can these problems be anticipated? The answer, regrettably, is that anticipation will be possible only at a broad and general level, if at all. Many of these problems arise at obscure places in the procurement cycle. It is unlikely that a general review of a regulation will reveal that the sole source (a sub-contractor three or four times removed from the prime contractor) for a chemical used only in one kind of battery will have to close due to new exposure limits. And, even if that could be anticipated, the warning might cost more than the savings resulting from the warning. But some anticipation at a general level might prove fruitful. Even a superficial survey of potential problems, if circulated to project managers and other cognizant officials within DoD, could serve to raise the right questions and focus attention potential areas of concern. They would almost certainly be

more meaningful than circulating the detailed mass of regulations and hoping for a meaningful response.

As was pointed out above, EPA and OSHA do not conduct any systematic reviews of the effects of their regulations on DoD. Nor does DoD do so itself--at least not with any emphasis on DoD's ability to procure materials. The
and the Defense Logistics Agency review proposed regulations for technical accuracy and comment on whether there is a need for the standard from a health and safety perspective. The DASD(EE&S) coordinates these comments and provides testimony at public hearings when necessary. The effect on DoD contractors, and hence, on DoD weapon system delivery is too tenuous for a quick review of this sort to provide much of value. The Materials Availability Steering Committee has made some efforts, however, to have industry advise it of particular problems it anticipates from EPA/OSHA regulations by solicitating comments from industry associations and trade groups. This raises well-founded fears that DoD could unwittingly become a tool of special interests if the utmost case is not exercised in weighing these comments.

The logical place for a general review of potential adverse effects on DoD is within the regulatory agencies. The reviews they currently conduct to determine control technologies are highly technical and involve them deeply in industries' production methods; their economic impact studies involve them in industries' markets. Only minor changes of emphasis can raise significant questions about the military implications of the controls. Certainly these should be conducted if a regulation affects "defense-oriented" industries as defined by the Bureau of the Census.[1] Its objective should be to raise a range of potential problems which might mean something to the program

[1]The Bureau of the Census annually surveys a series of "defense-oriented" markets in its MA175 reports. These markets involve either large defense outlays or are critical to the Defense Department in some respect other than volume.

managers or procurement officials in DoD who are buying in these markets.

The current procedures for responding to a problem imposed by regulatory agencies have been broadly outlined above. The program manager and the military department are responsible for the problem and its resolution unless it cuts across service lines. If more than one service is involved, OUSDR&E assumes a coordinating role. The process is *ad hoc*, as are the solutions. Depending on the problem, it might never surface at the headquarters level, or it could land on a number of different desks. Two program managers, faced with the same problem, may seek completely different remedies. The same problem may result in different symptoms in different situations, and the problems may never be recognized as being the same.

Since it is impossible to anticipate all of these problems, it is going to be easier and cheaper to simply respond to many of them as they occur--if it is possible to respond effectively. To do this, a focal point for such problems needs to be established and generally recognized. Experience with these problems has indicated that the proper ways and means for coping with them are almost always available. Ultimately, the problem becomes one of changing a specification, adopting irregular procurement procedures, or looking for additional funds--actions for which established channels exist. But it is difficult and time-consuming to work from the field where these problems arise through the bureaucratic maze that controls the solution. The value of the focal point would be experience in handling these problems, and a working knowledge of both potential solutions and the people or groups who have the power to implement the solution. The focal point (perhaps only one person with other responsibilities for providing guidance on material or procurement problems) needs to have limited power to resolve the problem, knowledge of possible solutions, knowledge of how to

document the need for a remedy, and the ability and authority to implement it.

The Materials Availability Steering Committee comes very close to filling this role. It is a group of experts on exactly these issues. Unfortunately, the persons who serve on the Committee also must assume heavy responsibilities in other areas; they have relatively littel time to devote to this specific problem area, and cannot generally make themselves available to solve other individuals' problems. It a focal point is to be established, it should work intimately with the Committee and its members, and should itself be a member. The focal point would need the Committee's backing, since the prestige and influence of the Committee members would be necessary to make the position work effectively.

The fact that many of these problems are the concern of OUSDRE suggests it as the proper focal point for these problems. And the fact that the offices of several Directors within OUSDRE currently share responsibility for parts of this problem suggest that coordination and action would require authority from the Office of the Deputy Under Secretary for Acquisition Policy. The position would be member of the Materials Availability Steering Committee; it would not replace the members from the relevant DoD Offices, only subsume their authority with respect to specific regulatory problems. The effect of establishing a focal point for these problems would be to provide some continuity and expertise in resolving problems of a recurring nature. It would also eliminate duplication of effort if the proper office for help with such problems were clearly designated. Even if all of the problems in this area cannot be anticipated, they can generally be dealt with more effectively once they are recognized.

C. EFFECTS ON CAPACITY

EPA and OSHA regulations do result in some closings and reduced capacity. This raises two questions relevant to the Defense Department. Can descriptions of delivery schedules and lengthening lead times be reduced? In part, this is answered by our comments above concerning the administration of these problems, but an additional specific comment on the Defense Priority System is warranted. The second question is whether reduced capacity in many basic areas adversely affects "surge" capacity for a mobilization. Does it reduce production capacity to precarious levels?

1. The Defense Priority System

The Defense Priority System (DPS) offers a priority system which gives DoD preferential treatment on the order-boards of many manufacturers.[1] Authorization for DPS ratings stems directly from the President, with authority delegated through the Federal Preparedness Agency, Department of Commerce, the Office of the Secretary of Defense, the military departments and, finally, to the relevant contract officer. The contract officer may designate any item with a priority as specified in DPA regulations. This priority is passed on by the main contractor to all sub-contractors; the requirement on sub-contractors is "self-authorized" by the initial priority. All orders are assigned a manufacturing priority with a designated delivery date. Non-compliance is investigated by the Department of Commerce, and criminal penalties are endorceable for a refusal to comply.

This system is a powerful tool for coping with general supply shortages. It gives DoD preferential placement for

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[1]U.S. General Services Administration, Federal Preparedness Agency, "The Federal System for Managing Shortages of Materials in National Emergencies" (February 1978), pp. 14-16.

orders, and it gives the force of law to that placement. When properly used, and especially when used in conjunction with foresight generated from the anticipation of some of these problems as suggested above, it can prevent snarls in production and lengthening lead-times from significantly impacting DoD acquisition. Recent efforts by the Navy to ensure the application and enforcement of ratings on steel and non-ferrous castings have apparently worked well and reduced lead-time for ship construction.[1]

2. Mobilization Capacity

Discussions of capacity in a National Defense context immediately bring to mind mobilization requirements. It is important to note, however, how our perspective alters when we turn from day-to-day operations discussed above to mobilization or "surge" requirements. In peacetime, it is safe to assume that the defense market is small compared to overall capacity in most markets. The peacetime problem is one of competing with the civilian market, assuming civilian requirements take care of themselves. In wartime the non-essential civilian market can be significantly reduced, but it is important that swelling DoD needs do not displace essential civilian output. Much seemingly civilian output is vital to wartime production, e.g., a machine tool with no military application may still be necessary to produce valves for locomotives to deliver war materiel. Capacity for wartime must incorporate all of these kinds of output and not focus on military production only.

The Federal Preparedness Agency uses input-output methods to project mobilization requirements for many strategic and critical materials.[2] We have adapted this method to project

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[1]Telephone conversation with K. R. Foster, formerly with the Navy Shipbuilding Scheduling Office, Philadelphia, Pennsylvania.

[2]U.S. General Services Administration, Federal Preparedness Agency, "Stockpile Report to the Congress, April-September 1977" (April 1978).

the mobilization requirements for iron and steel castings in a mobilization. The method is quite simple. Let a_i be the tons of casting used per dollar of shipment by the (i)th industry;[1] let s_i be the dollars of product shipped. Then total requirements (R) for castings by all industries are simply:

$$R = \sum_i a_i s_i .$$

The shipments for peacetime and wartime for 176 industries was estimated using the INFORUM model.[2] The wartime scenario is similar to that used by FPA for their stockpiling studies, and the National Income Accounts assumed are shown in Table III.2.[3]

The difference between peacetime and wartime requirements for both iron and steel castings is shown in Table III.3. Wartime requirements for iron castings rise by 12.3 percent over peacetime, the increase for steel is 11.5 percent. These basic wartime figures are subject to modification if various measures are adopted. Table III.3 shows how casting shipments could be modified if four different policies were adopted.

> Policy 1: Increase defense spending by $24 billion. This simply illustrates the sensitivity of this market to DoD requirements. This increase in spending raised iron casting shipments by 1.2 percent, and steel shipments by 3.3 percent.
>
> Policy 2: Impose civilian austerity and cut personal consumption by six percent. This has only small effects on both markets for castings.

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[1] This was estimated for iron and steel castings using Table 5D of "Selected Materials Consumed," *1972 Census of Manufactures* MC72(1)-5 (December 1975). There were no adjustments made for changing technology between 1972 and 1978; a more realistic effort might want to incorporate such changes.

[2] C. Almon, *et al., 1985; Interindustry Forecasts of the American Economy,* (Lexington, Mass.: Lexington Books, D.C. Heath and Co., 1974).

[3] R. W. Gilmer and P. F. McCoy, "An Assessment of Computational Procedures to Determine Requirements of Critical and Strategic Materials," P-1238, Institute for Defense Analyses, Arlington, Virginia (1977).

Table III.2. ASSUMED NATIONAL INCOME ACCOUNTS FOR PEACETIME AND WARTIME, 1978

(Billions of Dollars)

USES OF INCOME	1978 PEACETIME	1978 MOBILIZATION
GROSS NATIONAL PRODUCT	1338.3	1564.3
PERSONAL CONSUMPTION	845.6	879.6
Durables	141.7	163.4
Nondurables	334.0	358.7
Services	370.7	357.7
GROSS PRIVATE DOMESTIC INVESTMENT	203.3	207.1
Fixed Investment	194.2	146.7
Structures	35.7	42.0
Producer's Durable Equipment	87.2	104.7
Residential	31.4	30.8
Change in Business Inventory	9.1	30.6
GOVERNMENT PURCHASES[a]		
Federal	59.7	90.5
State and Local	94.6	92.6
NET EXPORTS	6.7	13.1

[a]Goods only, compensation is not shown.

Table III.3. PEACETIME AND WARTIME REQUIREMENTS FOR IRON AND STEEL CASTINGS, 1978

(Millions of Tons)

Scenario	Iron	Steel
Peacetime	8667	1231
Wartime	9731	1373
Policy 1	9850	1419
Policy 2	9691	1367
Policy 3	9562	1351
Policy 4	6592	1272

Policy 3: Do not cut personal consumption spending (PCE), but shift 30 percent of durable goods expenditure to non-durables. This does have a larger effect than simply cutting PCE, but it is still not highly significant.

Policy 4: Stop all civilian production of automobiles. This policy leaves a 30 percent surplus in iron casting capacity, and only a 3.2 percent increase over peacetime needs in steel capacity.

Policy 4 makes it clear that emergency measures modeled on World War II could fill much of the gap in capacity for iron and steel castings. Combining several of these policies and selective substitution could probably bring peacetime and wartime requirements into line with each other.

While these results indicate that no pervasive problem exists, this does not mean that the problem can be completely dismissed. Castings for specialized purposes, such as very large castings or castings requiring special heat-treating, may require specialized facilities, and specialized skills may be necessary for some of this unique production. Recent Army difficulties in procuring very large forgings and castings for tank turrets and body parts have highlighted this kind of problem with DoD.

Appendix to Chapter I

ESTIMATING THE AGGREGATE IMPACTS OF POLLUTION CONTROL COSTS

This report suggested that there were two ways for the Department of Defense to keep track of the effect of regulatory problems. One was to accept the fact that many detailed problems could be dealt with only in a defensive mode--waiting for the problem to surface, but having an effective mechanism in the form of a focal point to respond to the problem once it did surface. The other was to remain aware of the problems at a more general level in terms of the economic impact these regulations must have. The calculations used throughout Chapters I and III of the report illustrate the kinds of general questions that can be answered. Which industries are heavily impacted? Where are direct price increases highest? Where are total price increases highest? Which defense-oriented industries are heavily affected? What will be the effect on the DoD budget of pollution or other regulatory controls? The purpose of this appendix is to carefully document how these general questions can be answered at relatively detailed levels and on a recurring basis.

The emphasis of the appendix is on the methodology used to estimate the impact of regulatory constraints and it provides a rather general guide to deriving these estimates. The data to actually implement these estimates are available from numerous published sources, and much of it is currently assembled in readily usable form by several organizations.

(1) The best documented and most current set of data on the inter-industry structure of the United States is maintained by the INFORUM project at the University of Maryland. The INFORUM project has generated more than just a useful set of data, however. An equally important aspect of the project has been the development of a forecasting model that is capable of subsuming almost all of the methodology discussed here.

(2) Chase Econometrics uses the INFORUM model in ways that are very similar to those which would most interest the Department of Defense. Chase annually estimates the economic impact of pollution control on macroeconomic variables, and builds the estimates from detailed industry data on pollution control. The detailed industry data is that required for the DoD estimates.

(3) The Federal Preparedness Agency estimates the mobilization needs of the Department of Defense for various strategic and critical materials. The methods it uses to estimate these needs employ a data base and model analytically similar to INFORUM though it is less well maintained.[1] The analytical similarity of procedures and the experience of this organization in defense matters makes it an obvious choice to provide support for an effort of this kind.

The methodology which is outlined here is the same as that used in Chapters I and III. We used a small (12 x 12 sector) input-output model for purposes of our example, and much more detail can be attained at only a minor computational cost. The fact that so many data are readily available makes the implementation of the methodology a relatively simple matter. The following sections outline the assumptions and methods used to consider the cost of regulation to an industry, the price changes resulting from these new costs, and the new costs imposed on the Department of Defense.

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[1]R. W. Gilmer and P. M. McCoy, "An Assessment of the Computational Procedures to Determine Requirements of Critical and Strategic Materials," P-1238, Institute for Defense Analyses, Arlington, Virginia (1977).

A. FINANCIAL MARKETS

Financial markets are assumed to be perfectly competitive from both the point of view of the borrowing firm and the source of the funds. No firm can affect the price of securities by entering or failing to enter the capital market, and no lending institution can affect price by negotiating or failing to negotiate any loan or group of loans. Both borrowers and lenders accept the prevailing price of securities.

Firms can raise money by borrowing the funds or by selling equity in the firm in the form of stocks. Bonds offer tax advantages not attainable through equities as the interest payments can be written off in full against current income. The rate of return on bonds is r_b and the rate of return on stocks or equity is r_s; f_b and f_s are the proportion of the firm's liabilities financed as bonds or equity, respectively. The cash disbursement for capital is at a rate r, where

$$r = f_b r_b + f_s r_s \; .$$

Bonds offer tax advantages not attainable through equity sales as the interest payments can be written off in full against current income. If these tax advantages are considered the net cost of money depends on the rate x where

$$x = (1 - \tau) f_b r_b + f_s r_s$$

where τ is the marginal tax rate applicable to the firm.

The value of the firm (K) is the balance sheet definition of long term debt plus equity:

$$K = f_s K + f_b K$$

$$f_s + f_b + 1 \; .$$

The values of f_s and f_b are taken to be given to the problem by managerial decisions concerning the proper mix of debt and equity. Both factors will change over time and are tied to the financial history of the firm.

B. CAPITAL BUDGETING BY THE PROFIT-MAKING FIRM

Capital budgeting is the long-run optimization problem in economics where all factors of production are variable and the firm's problem is to choose a suitable scale of operations. The profit-making firm is assumed to make this long-run decision with careful consideration of its long-run implications, and specifically to assume that investment projects will be made so as to maximize the present worth of the firm. Two forms of constraints impinge on the decision-making process. First, there are technical constraints imposed by specific capital needs for the projects considered and represented generally by a production function. Second, the rate of growth will be affected by past investment decisions and the need to replace capital stock currently held by the firm.[1] To provide an exposition of the competitive firms' economic behavior, it will be convenient for us to make use of the symbols listed in Table A.I.

Gross revenue earned by the firm, $R = p\tilde{Q}$, is projected into the future for a particular capital expansion plan. The total liabilities (L) of the firm, excluding the potential profit to be earned by the owners of the firm are the sum of planned investment including working capital (I), operating cost including both operations and maintenance (O&M) and fuel

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[1]This general approach was developed in a long series of papers by Dale Jorgenson. For example, in "Capital Theory and Investment Behavior," *American Economic Review,* 53 (May 1963), or "The Theory of Investment Behavior," Universities-NBER Committee for Economic Research in *Determinants of Business Investment* (New York: Columbia University Press for the National Bureau of Economics Research, 1967), pp. 129-155.

Table A.I. NOTATION FOR COMPETITIVE FIRMS

Symbol	Measure	Interpretation
r	$/$	Market rate of interest
r_s	$/$	Rate of return on equity
r_b	$/$	Rate of return on bonds
τ	$/$	Marginal tax rate
f_s	$/$	Share of debt financed through stock or equity
f_b	$/$	Share of debt financed through bonds
R	$	Gross revenues
L	$	Liabilities incurred by the firm
D^T	$	Depreciation charged against income allowed by IRS for the recovery of capital
D^B	$	Book depreciation reflecting the true rate of capital consumption
F	$	Fuel costs
Π	$	Ad valorem charges, including property taxes, insurance, surcharges
T	$	Income taxes
O&M	$	Operating and maintenance cost
O	$	Total operating cost, O&M + Π
K	$	Capital stock of the firm
I	$	Investment of the firm
V	$	Unrecovered capital on which interest must be paid
q	$/unit	Market price of capital
s	$/unit	Unit operating cost
p	$/unit	Market price of energy product
d^T	$/$ or unit	Proportion of capital IRS allows to be written off
d^B	$/$ or unit	Proportion of capital consumed on the books
w	$/$	Proportion of book depreciation allowed for taxes
V	$	Amount of capital which is unrecovered
v	$/$	Proportion of unrecovered capital, V/K.
C	$	Cost of capital, normally less than the market price q
$\tilde{Q}_i$	units	Sales of the firms' output
$(\sim)$	units	Indicates that a variable normally measured in dollars is measured in physical terms, e.g., $K_i = \tilde{K}_i q$
i	time	Time variable, often a subscript

costs (F), ad valorem taxes (Π), a charge for capital consumed during operations (D^B), and income tax liability (T). At time (i) this is written:

$$L_i = I_i + O\&M_i + F_i + \Pi_i + D_i^B + T_i.$$

Income taxes are levied on gross profits at a rate τ.

$$T_i = \tau(R_i - O\&M_i - F_i - \Pi_i - D_i^T - r_b f_b V_i).$$

The last two terms inside the parentheses reflect provisions of the tax law which: (a) allow for depreciation for tax purposes (D^T) to proceed at rates different from the actual consumption of the capital stock, and (b) which allow interest payments on unrecovered capital (V) to be treated as current expenses.

For notational convenience below some further elaboration on these last two terms is worthwhile. The book depreciation charge D^B depends on the proportion of capital stock (d^B) used and the total capital stock (K),

$$D^B = d^B K = d^B q\tilde{K}$$

and $K = q\tilde{K}$ where q is the price and $\tilde{K}$ the physical units of capital held by the firm. Let w be the proportion of book depreciation allowed for taxes:

$$D^T = d^T K = w d^B q\tilde{K}$$

$$w = d^T/d^B.$$

For interest deductions, f_b is the proportion of debt financed by borrowing and r_b the return on bonds. The deduction allowed against income is

$$r_b f_b V = r_b f_b v q\tilde{K}$$

where $v = V/K$ is the proportion of loans outstanding and determined strictly by the payment schedule.

The problem faced by the firm, as we represented it above, is to maximize present worth

$$W = \int_0^\infty e^{-ri}[R(i)-L(i)]di$$

subject to technical constraints in the form of a production function

$$F(\tilde{Q},\ \widetilde{O\&M},\ \tilde{F},\ \tilde{K}) = 0.$$

Investment is measured net of replacement:

$$\dot{K}_i = I - d^B K.$$

Prices are assumed to be known parameters:

$$p\tilde{Q} = R$$

$$s\tilde{O} = s(O\&M+R)$$

$$q\tilde{K} = K.$$

The firm's discounted liabilities may be expressed as

$$L = \int_0^\infty \left\{ e^{-ri}\{R-L\} + \lambda_0(i)F(\tilde{Q},\tilde{O},\tilde{K}) + \lambda_1(i)[\dot{K}-I+d^B K] \right\} di$$

$$= \int_0^\infty f(i)di \qquad \text{where f is the term in brackets.}$$

Hence, the firm's net receipts may be expressed as

$$R - L = (1-\tau)\left\{[R-O\&M-F-\Pi] - q\tilde{I} - D^B - q\tilde{K}\left[wd^B + vf_b r_b\right]\right\}.$$

The relevant marginal conditions are

$$\frac{\partial f}{\partial \tilde{Q}} = e^{-ri}p(1-\tau) + \lambda_0(i)\frac{\partial F}{\partial \tilde{Q}} = 0 \qquad (1)$$

$$\frac{\partial f}{\partial \tilde{O}} = -e^{-ri}(1-\tau)s + \lambda_0(i)\frac{\partial F}{\partial \tilde{O}} = 0 \qquad (2)$$

$$\frac{\partial f}{\partial I} = -e^{-ri}q - \lambda_1(i) = 0 \qquad (3)$$

$$\frac{\partial f}{\partial \tilde{K}} - \frac{d}{di}\left(\frac{\partial f}{\partial \dot{K}}\right) = e^{-ri}\tau q \left\{ wd^B + vf_b r_b \right\} + \lambda_0 \frac{\partial F}{\partial \tilde{K}} + \lambda_1(i)d^B - \frac{d\lambda_1(i)}{di} = 0 \qquad (4)$$

$$\frac{\partial f}{\partial \lambda_0} = F(\tilde{Q}, \tilde{L}, \tilde{K}) = 0, \; \frac{\partial f}{\partial \lambda_1} = \dot{K} - I - d^B K = 0, \qquad (5)$$

where the λ's are Lagrange multipliers. Solving for the marginal conditions,[1] the firm will employ capital and operating variables up to the point at which

$$\frac{\partial \tilde{Q}}{\partial \tilde{O}} = \frac{s}{p} \qquad \frac{\partial \tilde{Q}}{\partial \tilde{K}} = \frac{c}{p}$$

where

$$c = q\left\{ \frac{d^B - \tau d^T}{1 - \tau} + \left(\frac{r - \tau f_b r_b v}{1 - \tau}\right) \right\}.$$

The unit price of capital prevailing in the market, q, is distinguished here from the rental price of capital, c. This rental price is adjusted for the tax effects of depreciation and debt finance. Importantly, it is the rental price and *not* the market price that the firm charges itself in the process of maximizing profits. The effects of the tax system are internalized by the profit maximizing the firm and used to reduce the cost of capital.

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[1]To solve, use (3) to solve for $\lambda_1(i)$ and substitute λ_1 and $d\lambda_1(i)/di$ into (4). Solve (4) for $\lambda_0 \partial F/\partial \tilde{K}$. Solve equation (1) for $\lambda_0(i)\partial F/\partial \tilde{Q}$. The ratio of this solution to $\lambda_0 \partial F/\partial \tilde{K}$ yields $\partial Q/\partial \tilde{K}$ - C/p and c(i) as shown.

- If tax and book depreciation coincide, the tax allowance for depreciation has no effect in differentiating the price of capital and the rental rate.
- Fast tax depreciation ($d^T > d^B$) is a subsidy from the tax system, and the rental rate falls below the price of capital.

C. PRICE CHANGES RESULTING FROM NEW COSTS

To compute the impact of these new costs, it is assumed that some fraction of these costs are passed through and become new, direct price increases. These estimates are based on historical responses and are available at detailed levels.[1] These price changes are then incorporated in an input-output framework and their implications for output, production, and price effects can then be examined.

The model of the economy used is the Leontief input-output model and its dual:

$$Ax + f = x$$

$$A'P + v = P$$

A = Leontief matrix reflecting technology. (More important for the needs here is that this matrix traces the pattern of interindustry transactions.)

f = bill of goods for final demand.

v = value-added by each sector of the economy.

x = total output of goods in the economy including the usual double-counting of goods.

P = unit price of x measured in an index of base period dollars.

GNP is measured as either the sources or uses of income:

$$\underset{\sim}{1}'v = \underset{\sim}{1}'f = GNP \qquad (\underset{\sim}{1} \text{ is a unit vector})$$

[1] David Gilmartin, "Forecasting Prices in an Input-Output Framework," INFORUM Research Report No. 16, University of Maryland (1976). These estimates were used in Table I.5 in Chapter I.

Output and prices are uniquely determined by f and v, respectively:

$$x = (I - A)^{-1}f$$

$$P = (I - A)^{-1'}v.$$

The model contains a simple labor theory of value.[1] Prices of products are assumed to be proportional to their labor content, $P = k\ell$, where k is an arbitrary constant and

ℓ = unit labor requirements vector
w = unit wage
$L = \ell'f$ = total labor requirements
$v = w\ell$ = value-added.

If the market is to clear, total wages must equal the value of output:

$$wL = P'f$$

$$w\ell'f = k\ell'f.$$

Thus k = w and price is equal to the value of labor in the product:

$$P = w\ell = v.$$

Assume that new pollution or safety/health requirements raise labor requirements for some industries[2] by an amount ℓ_0, so $\bar{\ell} = \ell + \ell_0$ measures new total labor requirements. Since price is proportional to labor content, the price of those products affected by new regulations rises by an amount $\emptyset^{(0)}$:

$$\emptyset^{(0)} = w\ell_0.$$

[1]K. Lancaster, *Mathematical Economics* (New York: Macmillan, 1968), p. 90.

[2]Labor is construed widely to include the labor "embodied" in the new capital requirements.

This is not the end of the price increases however. Every producer finds himself subject to this cost increase and raises prices to pass these cost increases through to the consumer. This new price change is:

$$\phi^{(1)} = A'\phi^{(0)}.$$

This is the sum of all price increases in $\phi^{(0)}$ weighted by the purchases each firm makes in production. If these costs are passed through again, then new rounds of price increases result:

$$\phi^{(2)} = A'\phi^{(1)} = A'^{2}\phi^{(0)}$$

$$\phi^{(3)} = A'\phi^{(2)} = A'^{3}\phi^{(0)}$$

$$\vdots$$

$$\phi^{(n)} = A'^{(n-1)} = A'^{n}\phi^{(0)} .$$

Producers accept cost increases and pass them on as product price increases at each round. The total price increase resulting from the initial triggering of this process with $\phi^{(0)}$ is:

$$\begin{aligned}\phi &= \phi^{(0)} + \phi^{(1)} + \phi^{(2)} + \ldots + \phi^{(n)} \\ &= (I + A + A^{2} + \ldots + A^{n})'\phi^{(0)} \\ &= (I - A)^{-1}{}'\phi^{(0)}.\end{aligned}$$

The total price increase is a multiple of the initial price increase and is a function of the interindustry structure.

The initial price level was P and after the changes work their way through this system, it is $\overline{P} = P + \phi$ and the change in total national money income is:

$$\phi^{(0)'}(I - A)^{-1}f.$$

If f = c + d, where c is personal consumption and d is purchases by the Department of Defense, the price increases imposed on the Defense Department are:

$$\phi^{(0)\prime}(I - A)^{-1}d.$$

The vector d was estimated for some defense-oriented producers in Chapter III using the MA-175 survey data "Value of Shipments by Defense-Oriented Industries." These surveys normally run two or more years behind current events and both the Federal Preparedness Agency and the INFORUM project attempt to keep more up-to-date and comprehensive figures. The estimates combine the MA-175 data with projections of the defense bill-of-goods from other sources.